
Introduction

The Electronic Switched Network (ESN) is a private communications network intended for use by large business customers with distributed operation locations. See *Electronic Switched Network description* (309-3001-100).

This Northern Telecom Publication describes the signaling guidelines and considerations applicable to Electronic Switch Networks (ESNs). You can use the information presented here to determine the compatibility of a switch that is to be incorporated as part of an ESN network. To determine transmission requirements, refer to *Electronic Switched Network transmission guidelines* (309-3001-181). Use this companion publication in conjunction with this publication.

PBX networks

PBX networks have three basic elements:

- telephones
- a PBX switch
- transmission facilities

Each telephone is connected to a PBX switch that establishes connections between the telephones. Connections between telephones on different switches in a PBX network are established over a transmission facility (such as a trunk) between the pair of switches, or over a tandem connection of transmission facilities and intermediate switches.

A user establishes a call to another telephone by dialing a string of digits that direct the connection to that telephone. In tandem tie trunk networks (TTTNs), the dialed digits steer the connection through the network. A string of successive access codes cause facilities to connect in tandem until the switch that connects to the destination telephone is reached. Each time a switch connects a new facility in tandem, it passes on the digits to the connected facility.

In a Meridian 1 network, the Electronic Switched Network (ESN) node switches collect all digits of the called number, and pass the full-called number between switches. The called number is dialed in a Uniform Dialing Plan (UDP) format. Users at switches connected to Meridian 1 ESN nodes may have to dial in a tandem tie trunk network (TTTN) format to reach the node before dialing the called number in UDP format. Similarly, the ESN node may control routing to connected switches by transmitting a sequence of access codes, followed by the called number.

Switches are also provided with trunks to the public network. Calls to telephones in the public network (and to other switches) can be placed by these trunks. However, trunks between switches (tie trunks) are normally provided because the calling can be performed at a lower cost.

PBX designations

PBX switches in a network configuration have designations that depend on the network function. Designations used include the following:

- node
- main
- satellite
- Common Control Switch Arrangement (CCSA) tandem

Node switch

Node is the designation in an ESN network for a Meridian 1 switch with the ESN Network Alternate Route Selection (NARS) software package. The Meridian 1 ESN node has the full capabilities for selecting trunk routes, while other non-mode switches have only limited route selection capabilities.

Main switch

A main switch is a switch that has an outgoing trunk route to only one node. This route can be both incoming and outgoing, but routes to other nodes must be incoming only to the main PBX, since the main PBX cannot select between nodes for the routing of network calls. A main PBX can have central office (CO), foreign exchange (FX), and wide area transmission service (WATS) trunks, as well as tie trunks to other switches.

A PBX that has outgoing trunk routes to more than one node, but does not meet the requirements for classification as a node, is also classed as a main PBX. The outgoing routes can be assigned different access codes, leaving route selection to the user, or can be selected by an automatic route selection capability.

Tributary switch

A tributary switch is a PBX that has a trunk route to a main PBX, but not to a node. A tributary PBX can have central office (CO), foreign exchange (FX), and wide area transmission service (WATS) trunks, as well as tie trunks to other switches.

Satellite switch

The only difference between a satellite and tributary PBX switch is that the satellite switch has neither incoming central office (CO) trunks nor attendant service. In this document, satellite and tributary PBX switches are treated the same.

CCSA tandem switch

A Common Control Switch Arrangement (CCSA) tandem switch is the major switching vehicle in a CCSA network. The tandem switch performs trunk to trunk switching only. Its function is similar to that of a Meridian 1 ESN node, except that a Meridian 1 ESN node can support telephones in addition to trunk to trunk switching. Switches with tie trunks to the tandem switch are called main switches. The CCSA network supports a dialing plan similar to the ESN Uniform Dialing Plan (UDP).

The Common Control Switch Arrangement (CCSA) tandem switch is the interface point between the ESN network and a CCSA network. The two networks can be arranged to function as a single integrated network.

Supervision

Supervision is a binary signal associated with each direction of transmission on a trunk facility. The two states are on hook and off hook, analogous to the condition of a telephone on hook (hung up) or off hook (in use).

Each switch connected to a trunk sends a supervision signal to, and receives a supervision signal from, the connected switch. Thus, the trunk has four supervision states. The trunk is idle when both directions are on hook. Off hook is sent when a call is initiated on an idle trunk. This action is called “seizing” the trunk. The distant switch receives the off hook signal and prepares to receive digits. A momentary off hook condition returned from the destination switch can occur during call setup, but a steady off hook is not transmitted until the called telephone answers. This off hook signal is called “answer supervision.” The supervision changes to on hook when the called telephone hangs up or is disconnected.

When a switch serves as an intermediate (tandem) connection between trunks, it normally sends the supervision signal it receives from each incoming trunk to the connected outgoing trunk. It also monitors for a disconnect signal so that the trunks can return to an idle state and wait for new calls.

In some cases, no provisions are made for returning an answer supervision signal from the destination when the called telephone answers. If this occurs, an off hook signal can be returned from an intermediate switch. This off hook signal is called “substitute answer supervision.” This signal is provided to remove transmission impairments associated with the on hook condition on some trunk facilities and to distinguish a call that has been blocked from one that might have reached a destination party.

A connection by a public network trunk is a typical case where a called telephone answer indication is not returned. The PBX switch that connects the call to the public network trunk must be configured to provide an off hook signal to the incoming trunk after sending digits to the public network trunk.

Digit transmission

In an ESN network, digits of the called number are transmitted between pairs of switches in one of two modes:

- dial pulse (DP)
- dual tone multifrequency (DTMF)

In dial pulse (DP) mode, each digit is represented by a string of pulses. The digit 0 is represented by ten pulses. Each other digit is represented by the corresponding number of pulses. The pulses are transmitted as interruptions of direct current.

In dual tone multifrequency (DTMF) mode, digits are transmitted over the speech path by a tone code. Digit transmission takes place at a higher rate than dial pulse (DP) mode (typically two to ten times faster).

Modern PBX switches are compatible with either mode. Older equipment is only compatible with DP mode. ESN uses dual tone multifrequency (DTMF) mode wherever practical, to take advantage of its higher transmission speed. However, DP mode is sometimes required. Furthermore, there are some transmission impairments associated with DTMF. These impairments are normally only important when equipment is still connected after conversation begins to take place. The impairments are removed when the receiving equipment is disconnected.

Modes of operation

A PBX switch can operate in one of two modes when routing a call over a tie trunk:

- cut-through
- senderized

Cut-through mode

With cut-through mode, a trunk is accessed immediately following an access code. Subsequent digits are forwarded to the trunk as dialed. The telephone user monitors call progress tones from connected switches. Because of a blocking tone, the user may be required to pause in dialing to monitor for a dial tone, or may be required to abandon the call before completing dialing.

Pure cut-through mode provides the greatest flexibility for providing compatible operation for calls originating at main and tributary switches. The number of digits transmitted to the node can be flexible. The node can prompt for additional digits when required for the authorization code features.

DTMF to DP conversion

A variation on cut-through mode is to provide DTMF to DP conversion. The user dials DTMF digits, but DP are transmitted to the trunk. The converter can block transmission in the caller to called party direction while waiting for digits. The converter can detach to remove these transmission requirements. Because the last digit can not be detected easily, timing is often used to determine the end of dialing.

When the switch has completed outpulsing, it waits a specified time for additional digits. If no digits are received in that interval, conversion is disabled. The timing may not properly distinguish a pause in dialing from a last digit, prematurely canceling the forwarding of digits. Extending the timing causes transmission impairments during conversation if the called party answers quickly.

The Meridian 1 ESN nodes combine cut-through and senderized modes of operation. The switch collects the access code and enough digits to select a trunk. During this interval, the operation is very close to a register sender mode. The trunk is accessed and a string of digits outpulsed (not necessarily the same as those dialed). Subsequent digits are forwarded to the trunk as dialed, in a receive and resend mode, which is closer to cut-through operation.

Senderized mode

With senderized mode, all digits of the called number are collected before an outgoing trunk is accessed. The trunk is accessed, and digits are transmitted to set up the call. The transmitted digits need not be the same as those dialed for example, as a result of Network Alternative Route Selection (NARS) digit manipulation. The user does not receive call progress tones until all digits are transmitted. No tones are provided during dialing other than a locally generated dial tone following the trunk access code.

Senderized mode limits flexibility. The main PBX must be programmed to determine how many digits to collect before forwarding those digits to the node. Usually, no more than 12 digits can be collected and forwarded.

Outpulsing control

After a tie trunk is seized, digits of the called number are normally transmitted. The only exception is a manual trunk, which rings a designated telephone when seized. However, most terminating equipment requires a variable time interval to prepare for the reception of digits. This time interval often depends on the switch's call-processing load. Therefore, a fixed delay before sending digits is unreliable. There are four commonly used ways of handling start dial control, as described in the following sections.

Immediate start

Immediate start applies in those cases where a short fixed delay is required for the switch to prepare to receive digits.

Delay for dial tone

A dial tone is provided when the switch is ready to receive digits.

Wink start

A momentary off hook signal is sent when the terminating equipment is ready to receive digits.

Delay dial

An off hook signal is sent to signify that the switch is not ready to receive digits. An on hook signal is sent when the switch is ready to receive digits.

The delay for dial tone is used when a user controls digit sending, as in a tandem tie trunk network (TTTN). Wink start and delay dial are used in registerized digit sending. Normally, only one start dial control is used. However, on some switches, a dial tone may be combined with any of the other three.

The Meridian 1 switches in an ESN network can work with any of the start dial signals.